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Denominate numbers used in the factories of New Britain

Boston University

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Thesis

Denominate Numbers Used In The Factories Of New Britain

Submitted by

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Table of Content

Introduction

A. Purpose

To discover what units of measure are used in four typical New Britain industries, and how they are used, with a view of supplementing other studies as to what the schools should do about denominate numbers.

B. Addresses of Companies

1. Fafnir Ball Bearing Co.

   37 Booth Street — New Britain, Conn.

2. P. & F. Corbin Co.

   67 Park Street — New Britain, Conn.

3. The Stanley Rule & Level Co.

   111 Elm Street — New Britain, Conn.

4. The Vulcan Iron Works

   60 John Street — New Britain, Conn.

C. Men Interviewed

In this study four typical New Britain industries have been used as a basis for the study of denominate numbers. The date were gathered by observation and interviews with the following men;

Mr. Howard Rawlings	P. & F. Corbin Co.
Mr. H. T. Middlemass	P. & F. Corbin Co.
Mr. Gordon Ely	Fafnir Ball Bearing Co.
Mr. H. G. Higbee	Stanley Rule and Level Co.
Mr. William Clark	Vulcan Iron Works
Mr. A. Lecrenier	American Hardware Corp.

D. Outline

In this study the following outline has been used as a basis for the study of each factory:

1. General history of the company
2. Articles purchased by the company and units used
3. Articles manufactured by the company and units used
   a. The manufacturing of one article
4. Accuracy of measurements in manufacturing
5 Measurements used in the selling of articles
6. Summary

Bibliography

1. History of New Britain Industries — Chamber of Commerce
2. Corbin Line of Door Checks — P. & F. Corbin Co.
3. Fafnir Ball Bearings — Bulletin #7 — Fafnir Ball Bearing Co.
4. Stanley Tools — Bulletin #34 — Stanley Rule and Level
5. Fafnir Ball Bearings for Frames and Twisters — Fafnir Ball Bearing Co.
6. Ball Bearings for Automobiles — " " " "

The Fafnir Ball Bearing Company

The Fafnir Ball Bearing Company is one of the infant factories in the family of New Britain industries. Starting in 1911 with a total office and factory force of seven people, working in a corner of the Hart and Cooley plant, it now has on its payroll over seven hundred names and occupies a floor space of nearly four acres.

As early as 1909, the idea was conceived that a ball bearing could be made in America as well as in Germany and acknowledging at that time the pre eminence of European, especially German methods of manufacturing, the local organizers went to Germany to study processes and to make arrangements for securing suitable raw material.

The products of the company were first sold through an importer of German bearings. By reason of this close contact with competing European articles, by constant tests and comparison, it was soon discovered that a ball bearing of American manufacture could be made the equal to the imported article, and that, with the protection of a reasonable tariff, the American article could be sold in competition with the foreign article in domestic markets.

The outbreak of the war and the consequent stoppage of all importations from Europe naturally lead to increased demand for domestic bearings from those hitherto dependent upon foreign made articles. The Fafnir Bearing Company dissolved its association with an importing agency and established its own selling force.

The Fafnir Ball Bearings are manufactured of a high grade of alloy steel which is hardened throughout. The steel treated in this manner is exceptionally hard and tough

without being brittle, and is ideally adapted to ball bearing service.

All steel is physically inspected in regard to the pressure it will withstand. This is done in the factory through the use of huge presses. It is also tested on machines, automobiles, etc. for durability and length of service it will give. The metal is also chemically inspected in regard to the composition of the steel. It must have a certain percentage of carbon and mollybedium. The heat treatment in the furnaces is carefully checked and regulated by constant supervision.

All Fafnir Ball Bearings of the line mentioned in this paper are made to internationally standardized dimensions and are interchangeable with other American and Foreign makes. Table I is an extract from the interchangeability table which all ball bearing manufacturers have. Take the Fafnir Ball Bearing (single row) as a means of comparison. This bearing has a bore of 10 millimeters, an outside diameter of 30 millimeters, width 9 millimeters. In ordering this bearing from the Fafnir Company one would give the number two hundred. If the order came in with other specifications as the S.K.F. or Hess Bright, it would be a simple matter to find the size of the bearing wanted.

Table I Interchangeability Table

1.	Fafnir	200
2.	Gurney Norman Hoffman	200
3.	Federal New Departure	1200
4.	S.K.F.	1200

5. Hess Bright 6200

6. Strom 5200

7. Schubert 5200

The following table gives the materials which the Fafnir Company purchases for the manufacturing of the Ball Bearings and the units in which purchased:

Table II

Materials Purchased and Measurements Used

1. Steel	Ton
2. Chemicals	Kilogram and Liter
3. Chemicals	Pound and Gallon
4. Coal	Gross Ton
5. Sand	Cubic Yard
6. Abrasive Paper	Gross
7. Fuel Oil	Gallon
8. Charcoal	Pound
9. Belting	Foot
10. Bricks	Per Thousand
11. Grease	Pound
12. Oils	Drums (Gallon)
13. Paints	Drums(")
14. Rubber	Pound
15. Instruments	Unit
16 Screws	Gross
17. Nails	Pound
18. Talc	Pound
19. " Pencils	Gross
20. Paper	Hundredweight
21. Cork	Pound and Inch[2]
22. Tin	Square Foot
23. Lumber	Board Foot

1. Dry chemicals by pounds, liquid by gallons. Sometimes acids are purchased by the pound.
2. Inches for width and breadth, pound for weight.

24. Alcohol Gallon

25. Wire Pound

Table III

Summary

Common Measurements Used In The Purchasing of Materials

Unit	Frequency	Unit	Frequency
1. Pound	7	8. Cubic Yard	1
2. Gallon	4	9. Gross Ton	1
3. Gross	3	10. Foot	1
4. Ton	1	11. Unit	1
5. Hundredweight	1	12. Square Foot	1
6. Board Foot	1	13. Kilogram	1
7. Inch	1		

There are two methods commonly used in the New Britain factory in the manufacturing of the Ball Bearing. One is known as the "hot-heat" method and the other as the "cold-point". In the former, small pieces of metals are placed in the furnace and heated to a white color. It is then taken out with a long-handled prong and placed upon an endless roller which takes it up to the first set of machines. Here the "cupper" takes the small bar and presses it together until it looks like a perfect sphere. After the process is completed, it is measured by one of the men operating the machine. It is then placed in a tray which carries it to a set of grinding and polishing machines. The first grinder takes off the outer rim which was made by the "cupper". It is then measured again by the use of the metric micrometer. There are a set of eight to ten machines which grind and polish, at the end of each process it is measured by one of the men and if it does not meet the specifications, it is reground or sent back to be

reheated and placed through a cupper. Throughout the entire process the men are continually checking the size of the ball bearing. It never leaves one machine to go to another without it being measured by one of the workmen or foremen. The machines are continually checked by operators. According to the superintendent of the plant, the men have to know how to measure accurately up to .0001 of an inch. After the bearings have gone through a series of polishers and grinders, they are placed in an assorting machine. From time to time bearings are taken from the machine and measured with the standard.

The cold method is where small chunks of steel are placed in a machine which has small cutters or chizels. The machine is set by the workmen. This machine gradually cuts off small pieces of metal. When the cutting process is completed it is placed through a similar set of machines as that previously mentioned. The men in this process continually check and recheck the settings of the machines and the sizes of the ball bearings.

As was pointed out by the superintendent of the plant, most of the men employed have to have an accurate knowledge of measuring with the metric micrometer to .0001 to .00001 of an inch. Every man working on the facing, race and grinding machines need an accurate knowledge of measurements. Over seventy percent of the men employed in this factory has been trained to use the finer types of instrument.

The Balls are accurate to a size of .00005 inches and are ground and polished to perfect sphericity by special gauging instruments. The grinding and polishing also assures a flawless surface. The outside measurements and external tolerances, are based on the standard specifications which are set up by the Society of American Engineers.

In order to separate in some degree the persons using accurate measurements from those who do not need great accuracy of measurements to carry on their daily work in industry, the following classifications are used:[1]

"First Class--- The men coming in this class are those who have an expert knowledge of the unit of measure, and who are using that knowledge in their work. These would be found in the die cutter, facing operators, etc., who need to know: how to measure with the micrometer, vernier caliper and other sensitive instruments; and formulae and techniques for measuring accurately all classes of work. This demands a special training and a minute degree of accuracy, often to .0001 of an inch."

"Second Class---This class is meant that having and using a knowledge of the common measure, such as linear, square and cubic and who are able to read simple blueprints. This class in general is composed of persons who measure the inch and foot accurately, but who are not expected to measure parts of an inch accurately."

"Third Class---These men do not need to understand any unit of measurement. These persons are usually engaged in press work, polishing, trucking, etc., where little fundemental knowledge of measurements is required, as machines are automatic and the process though important, does not demand the use of measurements."

The above specifications will be used in classifying the men employed by the Fafnir Ball Bearing Company.

Table IV

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1. From Master of Arts Thesis---- Boston University Graduate Sch. Units of Measurements in Industry---Mary deSales Louth--1931

Number of Men Employed Who Need to Know Various Degrees of Accuracy in the Manufacturing of the Fafnir Ball Bearing.[1]

Employes	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Superintendent	1	.007				
Ass't. "	1	.007				
Office Force					8	.01
Factory Foremen	30	.04	20	.02		
Shippers and Handlers					45	.06
Workers						
A. Trained						
Facing Operators	75	.12				
Grinders	55	.09				
Bore Operators	50	.08				
Race Grinders	75	.12				
Matching	25	.04				
Inspectors	5	.008				
B. Untrained						
Chipman					25	.04
Truckmen					25	.04
Work Handlers					53	.08
Polishers					16	.03
Inspectors					5	.008
Engineering and Designing	15	.03				
Tool and Repair	102	.16				
Totals[2]	434	.702	20	.01	177	.278

Number of men in the First Class 434

1. Accurate to March 28, 1931.
2. Following data were given by the Plant Superintendent

Number of men in the Second Class	20
Number of men in the Third Class	177
Total	631

Percentage of men in the First Class	.702
Percentage of men in the Third Class	.278
Percentage of men in the Second Class	.01
Total	.99 plus

The tabulations in Table IV, show an unusually large number of men falling in the first class specification. This is somewhat different from the other industries of New Britain. The work in the Fafnir Ball Bearing Company, as well as that in other ball bearing companies, requires an accurate knowledge of measurements in the metric system.

The following is a list of the different types of ball bearings manufactured by the Fafnir Company. The dimensions given are those used in manufacturing and selling of articles. The measurements used in the manufacturing of ball bearings are those of the metric system; however, for the convenience of the purchaser, the inch is usually placed beside the metric measurements. This holds true on their standard stock. On the bearings sold to the different automobile manufacturers, the metric system alone is used.

The following diagram will illustrate what is meant by the bore, outside diameter and the width of the ball bearing.

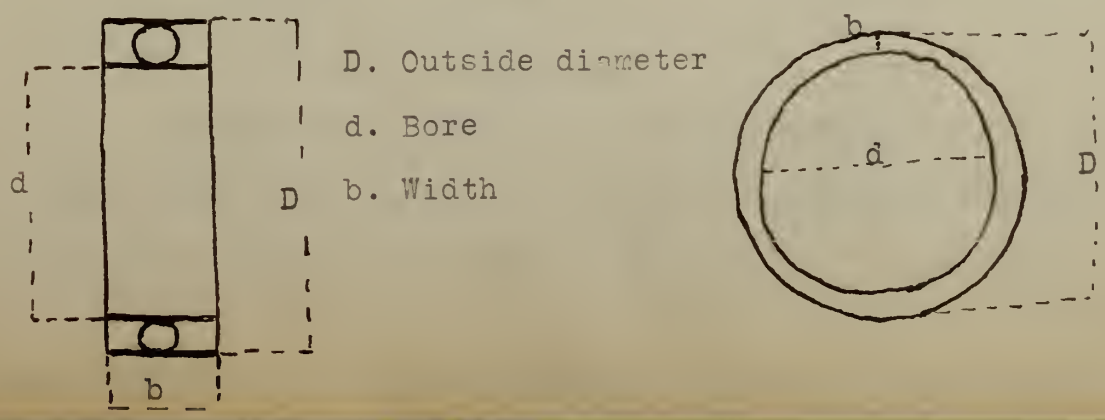

Table V

Measurements Used In The Sale And Manufacturing Of Ball Bearings

Bearing Number	Bore Diameter	Outside Diameter	Width
1. 200	10 mm.	30 mm.	9 mm.
2. 300	10 mm.	30 mm.	10 mm.
3. 400	17 mm.	62 mm.	17 mm.
4. 7200	10 mm.	30 mm.	9 mm.
5. 5220	10 mm.	30 mm.	9 mm.
6. Cloth Cutting Machine Bearings			
	25 mm.	30 mm.	7 mm.
7. Pierce Arrow Clutch Pivot			
	35 mm.	15 mm.	21 mm.
8. Oakland Buick Pinnion Shaft			
	30 mm.	80 mm.	21 mm.
9. Magneto			
	17 mm.	40 mm.	10 mm.
10. Paige Front Wheeling Bearings			
	40 mm.	90 mm.	1.24 mm.
11. 205kd (Radial)	52 mm.	25 mm.	15 mm.
12. 308s "	10 mm.	40 mm.	23 mm.
13. 5307d (Double)	90 mm.	40 mm.	1.6580 in.
14. 8307e "	30 mm.	80 mm.	1.3750 in.
15. w410hd (Radial)	80 mm.	30 mm.	1 3/8 in.
16. 414ac	180 mm.	70 mm.	42 mm.
17. 5308d (Double)	110 mm.	50 mm.	1.8287 in.
18. 321e (Radial)	225 mm.	5.250 in.	37 mm.
19. 310 "	10 mm.	40 mm.	23 mm.

In Table V, bearings numbering from one to five, are often sold by the inch. The Fafnir Ball Bearing Company does this for the convenience of the purchaser.

The following list gives the linear measurements used in the sale of bearings No. 1,2, 3, 4, 5 in Table V. These bearings are what the manufacturer calls the common stock.

Bearing Number	Bore Diameter	Outside Diameter	Width
1. 200	.3537 in.	1.1911 in.	.35431 in.
2. 300	.3937 in.	1.1911 in.	.3954 in.
3. 400	.6693 in.	2.4410 in.	.3534 in.
4. 7200	.3937 in.	1.1811 in.	.3534 in.
5. 5220	.3937 in.	1.1911 in.	.3534 in.

In the manufacturing of the ball bearing, the metric system is always used. In the selling of bearings, the dimensions of the larger ball bearings, especially the width, is expressed in inches. (See Tabel V, Item 13, 14, 15, 18, 20.)

Table VI

Measurements Used In The Manufacturing And Sale Of Bearings

	Frequency
A. Number of Bearings Tabulated	52
B. Manufacturing	
Millimeter	52
C. Sale	
Millimeter	52
Inch	20

Table VI shows that the millimeter is the most common unit of measurement used in the manufacturing and selling of bearings. The inch is used in special cases, as the common stock, in the selling of bearings. This is solely for the convenience of the purchaser in making comparisons. The inch is not used in manufacturing.

Having determined the measurements used in purchasing the raw materials, the manufacturing and selling of the bearings, the different units of measurements will be checked with the following table of denominate numbers.

Table VII

Tables of Denominate Numbers

Avoirdupois

16 ounces	1 pound
100 pounds	1 hundredweight
2000 pounds	1 Ton
2400 pounds	1 gross ton

Linear Measure

12 inches	1 foot
3 feet	1 yard
$5\frac{1}{2}$ yards	1 rod
40 rods	1 furlong
320 rods	1 mile

Square Measure

144 square inches	1 square foot
9 square feet	1 square yard
$30\frac{1}{4}$ " yards	1 square rod
160 square rods	1 acre
640 acres	1 square mile

Cubic Measure

1728 cubic inches	1 cubic foot
27 " feet	1 " yard
128 " inches	1 cord
8 cord feet	1 cord

continued-

Paper Measure

24 sheets	1 quire
25 sheets	1 printers8 quire
20 quires	1 ream
21 ½ "	1 printers' ream
2 reams	1 bundle
4 reams	1 printers' bundle
10 reams	1 bale
60 skins	1 roll of parchment

Measure of Angles and Arcs

60 seconds	1 minute
60 minutes	1 degree
90 degrees	1 right angle
360 degrees	1 circle

Unit Measurements

12 units	1 dozen
12 dozen	1 gross
12 gross	1 great gross
20 units	1 score
5 score	100

Metric Denominations

Weight

Millier	1,000,000 grams
Quintal	1,00000 grams
Myriagrams	10,000 grams
Kilograms	1,00[illegible] grams
Hectagrams	100 grams
Decagrams	10 grams
Gram	1 gram

continued-

Metric Denomination

dec gram	1/10 gram
Centigram	1/100 gram
Milligram	1/1000 gram

Measure of Length

Myriameter	10,000 meters
Kilometer	1,000 meters
Hectometer	100 meters
Decameter	10 meters
Meter	1
Decimeter	1/10 meter
Centimeter	1/100 meter
Millimeter	1/1000 meter

Board Measure

1 Board Foot	The contenets of a board 1 foot square and 1 inch thick

Liquid Measure

4 gills	1 pint
2 pints	1 quart
4 quarts	1 gallon
31½ gallons	1 barrel
63 gallons	1 hogshead

Summary

1. Advoirdupois	5 units
2. Linear Measure	6 "
3.Cubic "	5 "
4. Squa e Measure	6 "
5. Paper "	9 "
6. Measure of Angles	5 "
7. Unit Measure	6 "

8.	Metric-Weight	10 units
9.	" Length	8 "
10.	Board Measure	1 "
11.	Liquid Measure	6 "
	Total	67 units

Number of Tables of Denominate Numbers Used in the Fafnir Ball Bearing Company

A. Purchasing

Metric -- Length, Weight

Avoirdupois

Cubic

Unit

Board

Volume

Square

Linear

B. Manufacturing of Bearings

Metric-Length

C. Selling of Ball Bearings

Metric-Length

Linear

Total Number of Different Tables of Denominate Numbers used 11

A check up with the items listed in Tables III,[1] VI[2] and VII[3] show that ten of the tables listed in VII are used by the Fafnir Ball Bearing Company. However, never is a table of denominate numbers used in its entirety, only a unit.

In the Fafnir Ball Bearing Company only the following number of units are used from the tables of denominate numbers listed above. These are arranged according to purchasing, manufacturing and selling.

A. <u>Purchasing</u>

Avoirdupois 3 units

Ton (Used in the purchasing of steel)

Gross Ton (" " " " " coal)

Hundredweight (" " " " of rolls of paper. The inch is used for width)

1. page 4. 2. page 7. 3. page 11

2. Cubic 1 unit

Cubic Yard (Used in the purchasing of sand)

3. Unit 1 unit

Unit (Used in the purchasing of measuring instruments)

4. Board 1 unit

Board Foot (Used in the purchasing of lumber for boxes, flooring, etc.

5. Volume 1 unit

Gallons (unit used in the purchasing of chemicals and fuel oils)

6. Square Measure 1 unit

Square foot (Unit used in purchasing sheets of tin. Sometimes tin is purchased by the pound and length and width.

7. Linear 2 units

Foot (Commonly used as a unit of length in the purchasing of belting,etc.)

Inch (Usually used as a unit of width)

B. <u>Manufacturing</u>

1. Metric 1 unit

Metric-Length (Used in measuring the inside and outside diameter of ball bearings. It is also used in measuring the width of bearing.

C. <u>Selling</u>

1. Metric 1 unit

Millimeter

2. Linear 1 unit

Inch

The inch and the millimeter are both used in selling the ball bearing. Three dimensions are given, the inside

and outside diameter and width of the bore. The linear measure is used for the convenience of the purchaser only.

The measurements involved in the purchasing of materials need to be known by three men in the Fafnir Company. They purchase all articles listed in this study.

In the two tables of metric weight and length, only two units out of the possible eighteen are used. These are the millimeter and the kilogram, the latter used in the purchasing of foreign chemicals. The millimeter is the common unit of measurement in the Fafnir Company. All ball bearings are manufactured on the metric system.

A difference is noted in the measurements used in purchasing and manufacturing. On the whole, the measurements used in purchasing are those of volume and capacity. The measurement used in manufacturing is the millimeter which is used as a unit of length.

In making the ball bearing the millimeter is the only unit of measurement used. The majority of men in other New Britain factories need no knowledge in accuracy of measurements.

In the Fafnir Ball Bearing Company, 70% of the men employed need to know how to measure accurately to .00001 of an inch with the metric micrometer. These men have been trained in the factory in theeuse of the finer types of measuring instruments.

The P. and F. Corbin Company

The foundation of the P. and F. Corbin Company was laid in 1849, when the business began with the manufacture of hardware.

The first product was ox balls which were then in large demand. Lifting or drop handles were soon added, and other articles of miscellaneous hardware followed in rapid succession. Coffin trimmings and stove knobs formed at one time an important part of the assortment. In 1869, locks and knobs were added, and the future trend in this line was definitely determined. From that time on the additions have been in the line of finishing hardware for buildings of all kinds, other articles gradually disappearing with the specializing of manufacture, and the entire energy of the organization is now devoted to builders' hardware.

The growth of the concern has been fairly uniform through the years, slackening in dull times and accelerating in porsperous periods. It has taken on new goods as fast as need has arisen and has covered each line completely as to sizes and styles required. The unit lock is a Corbin invention.

The first factory was a small two-story frame building, with a cellar and a lean-to in the rear, the entire cost of the land and building being about $600. A horse tread-mill in the cellar supplied the power to drive the grindstone, an emery wheel and two lathes. There were two furnaces for casting in the lean-to. In 1852, additional space was required, and a room was rented in the factory of North and Judd. With the growth of the business, still more space was required and in 1864, the entire property was acquired. Since the building

after building has been erected, which has made it one of the largest in the country. To-day, the company employs over a thousand men and women.

It is important to know, in connection with any items that is sold, the exact character of the material from which it is made. The builders' hardware is made from iron and steel, and from alloys of copper, zinc, lead, tin and nickel. Most of this material is purchased by the gross ton except the tin, nickel and zinc.

1. Cast Iron hardware is made from "pigs" melted in the foundaries.

2. Wrought Iron hardware is made from sheets made to specifications, to combine proper strength and stiffness to stand the strain of forming without breaking. These sheets are ordered in number of square feet.

3. Wrought Brass and Bronze hardware is made from cooled rooled sheets of brass or bronze, made to their own specifications.

The highly competitive articles are made of wrought steel or cast iron, while the medium priced hardware is made of wrought brass or bronze.

In ordering the different articles from the factory, it is interesting to note that the company uses a number system. For instance, all wrought steel designs start with series of 600, wrought bronze design start with series of 700 and cast designs with figures of 740 or higher.

Each design is made of several pieces, such as knobs, escutcheons, push plates, etc. Each piece is distinguished by a terminal affixed to the design number, as, for instance, the

following, which are the final two figures of a five-figure number;

-22 Knob, $2\frac{1}{4}$ in. round

-29 Large Escutcheon, usually 10 inches long

-40 Key Plate

-90 Push Plate

These numbers represent a part of the items embodied in the various designs. In a complete number (Dover push plate 725-90, for instance) there are five figures.
7-brass or bronze metal: 25- Dover design: -90 push plate, equals 725-90.

The United States Department of Commerce in co-operation with the leading hardware manufacturers has issued the following table of sizes of butts for wood doors. They conform to the present general practice and represent the usual requirements for doors of different sizes and thickness.

Table VIII

Thickness in Inches	Width in Inches	Length of Butt
$\frac{3}{4}$ and 7/7 cupboard	to 24	$3\frac{1}{2}$ in.
7/8 and 1 1/8 screen	to 36	3 in.
1 1/8	to 36	$3\frac{1}{2}$ in.
$1\frac{1}{4}$ and 1 3/8 in.	to 32	$3\frac{1}{4}$ in.
$1\frac{1}{4}$ and 1 3/8 in.	to 37	4 in.
1 9/16, 1 $\frac{3}{4}$ and 1 7/8	Over 32 to 37	4 in.
" " " "	" 43 to 50	5 in.
" " " "	" " " "	6 in.
2, $2\frac{1}{4}$ and $2\frac{1}{2}$	to 37	5 in.
2, $2\frac{1}{4}$ and $2\frac{1}{2}$	Over 43 to 50	6 in.

The following are some of the technical terms as applied

to locks and builders' hardware.

a. Backset of a lock: The distance horizontally from the front to the center of the knob or key hole.

b. Pin Tumbler: A small sliding pin cut in two or more sections, worked by a key. When the right key is inserted the cuts in the tumblers are even with the case of the key plug, allowing some to turn, thus transmitting motion to the bolt.

c, Spindle: The shaft, usually square, which carries the knobs, and brings action to the latch bolt.

d. Strike: The plate which engages the bolt of the lock to secure the door.

e. Tumbler: That part in a lock which prevents the sliding of the door.bolts, until operated by the proper key.

f. Unit Lock: A lock constr cted so that all of its parts are permanently combined in a single unit.

g. Ward: A projection in the case or keyway of a lock, tending to obstruct the entrance of any key not having a like grooving or depression.

The weights given are supplied as a guide in estimating transportation and tariff charges. They include the weight of cartons and of any wrapping material used but do not include the weight of the wooden cases or of packing material.

The measurements are subject to the ordinary variations caused by grinding and finishing. When so ordered, goods are made to "template" for use on hollow metal doors and other places where accurate measurements are required for mortising and reinforcement, and blue print templets are furnished showing the exact dimension of the articles to be supplied.

The following table gives the materials which the P. and F. Corbin Company purchases in the manufacturing of hardware.

Materials Purchased and Measurements Used
(P. & F. Corbin Co.)

Table IX

1. Iron	Gross Ton
2. Hay	Ton
3. Straw	Ton
4. Coke	Ton
5. Brass	Pound
6. Copper	Pound
7. Aluminum	Pound
8. Leather Belting	Foot and Inch
9. Paints	Drums (gallon)
10. Chemicals	Pound and Gallon
11. Lumber	Board Foot
12. Steel	Ton
13. Screw Wire	Pound and Ton
14. Sand	Ton or Cubic Yard
15. Fuel Oil	Gallon
16. Bricks	Per Thousand
17. Rubber	Pound
18. Nickel	Pound
19. " Brass	Pound
20. " Silver	Pound
21. White Lead	Pound
22. Lacquers	Gallon
23. Glue	Pound
24. Alcohol	Gallon
25. Thinners	Gallon
26. Paper	Hundredweight and Inch
27. " (office)	Quire
28. Boxboard	Ton

29. Screws	Gross
30. Chemicals (Foreign)	Kilogram
31. Nails	Kegs (Pound)
32. Tar	Pound
33. Resin	Pound

Table X

Summary

Common Units of Measurements Used In Purchasing Materials

Unit	Frequency	Unit	Frequency
1. Pound	13	6. Kilogram	1
2. Ton	5	7. Gross Ton	1
3. Gallon	4	8. Hundredweight	1
4. Foot	1	9. Quire	1
5. Board Foot	1		

The Making of the Cast and Wrought Door Knobs.

The cast door knob is usually made of brass or iron. This material is purchased in pigs, usually by the ton.

The metal is placed in the furnace to melt. While this process is going on, men are filling small boxes with sand, which with a sticky substance constitutes the material in which the mold is to be cast. The casting of the mold takes place in the following way; A pattern is secured from the designing department and placed in the lower half of the box containing the sand molding material with the upper half of the pattern exposed. The upper section of the box is closed over the exposed half of the pattern. At the top of the box, a hole connecting with the center is left through which the hot metal is to be poured. The box is carefully taken off and the sand mold left on the floor. When the furnace is ready to tap, men fill their

ladles with the white hot fluid metal and pour it into the molds. This goes on until the liquid metal is disposed of.

When the molds are cool, the men break open the blocks by striking them with an iron rod. The hot sand falls away leaving the poured brass knob exposed. The knobs are gathered and placed in a solution to clean off the sand, a process which ix called gating. It is then taken to a milling machine which turns the knob and mills it to a specific size. Next it is measured for size by the use of a gauge. The solid brass heads are measured, centered, drilled, milled and tapped in a lathe or chucking machine. The gauges used in measuring this article are made by the tool department. The next operation is the polishing and buffing. It is then sent to the plating room to be surfaced and lacquerd; after which it is sent back to the knob room to be assembled. The assembling consists in fastening the two knobs with the spindle. They are assembled in pairs.

The wrought iron knobs are made somewhat differently. Strips of wrought iron are secured from the Stanley Works, which has its own cold presses and rollers. This metal is purchased by the foot and according to thickness, the latter usually meeting the requirements of a gauge .005 inches. Strips measuring from four to six inches are placed upon a racer which brings it to a huge stamping machine. This machine makes the upper shell of the door knob, while another makes the lower shell and neck. The two shells are then pressed together by a third machine and finally sent to the various rooms to be touched-up. In this process the men need only to feed the machine.

No measurements are required in the manufacturing of this product, since everything is set to the presser and the puncher.

In the making of the Cast and Wrought Door Knobs, no knowledge of measurements is required of the factory hand. The pattern is made by the designer, who is a trained and skilled man in this particular field.

Tolerances are based according to the American Society of Engineers. The hardware is usually accurate to .01 of an inch. In making hinges, the pin is usually accurate to .001 of an inch. This degree of accuracy is also necessary in making parts of the finer types of locks.

The following table will show the classification of men according to the specifications given on page 6.

Table XI

Number of Men Employed Who Need to Know Various Degrees of Accuracy in the Manufact ring of the P. & F. Corbin Hardware.

Employes	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Manager			1	.001		
Sales Manager			1	.001		
Works "	1	.001				
Production "	1	.001				
Stenographic Force					16	.01
Sales Department						
a. N.E. Sales Manager			1	.001		
b. Southern Sales Manager			1	.001		
c. Export Sales Manager			1	.001		

Employes	First Class No.	%	Second Class No.	%	Third Class No.	%
d. Chief Sales Clerk			1	.001		
1. Sales Clerk					2	.001
e. Contract Sales Clerk			3	.002	6	.004
Order Department						
a. Supervisor			1	.001		
b. Ass't. "					4	.002
c. Editors					9	.006
d. Typist					6	.004
e. Servcie Section					2	.001
f. Order Entry Dep't.					2	.001
g. Typists					6	.004
h. Stock Order Dep't.					7	.004
Invoice Department						
a. Supervisor			2	.001		
b. Typist					8	.005
c. Clerks					8	.005
d. Chasers					2	.001
Accounting Department						
a. Chief Accountant					1	.001
b. Bookeepers					4	.002
c. Bookeeping Machine O'rs.					6	.004
Factory Accounting Dep't.						
a. Chief Accountant					1	.001
b. Cost Clerks					6	.005
c. Time Study Clerks					4	.002
d. Clerks (girls)					7	.004
e. Paymaster					2	.001
f. " (girls)					2	.001
Filing and Mailing Dep't.						
a. Filing Clerks					7	.004

continued-

Employes	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
b. Mail Boys					4	.002
Factory Foremen	5	.003	18	.01	34	.02
Shippers and Handlers					18	.01
Workers						
a. Polishers					50	.03
b. Buffers					50	.03
c. Platers and Finishers					75	.05
d. Lock makers					150	.10
e. Machine hands					547	.37
(This includes pressers, millers, chuckers and filers)						
f. Inspectors						
1. Trained	10	.007				
2. Overseers					12	.008
g. Truckers					24	.017
h. Bench Hands (including assemblers, hand filers, etc.)					100	.07
Maintenance Dep't.			11	.007	11	.007
Power Plant					6	.004
Machine Tool and Die Dep't.						
a. Machinist	20	.014				
b. Tool Makers	30	.02				
c. Die Dep't.	30	.02				
Pattern Dep't.	29	.02				
Iron Foundry						
a. Molders					40	.025
b. Helpers					15	.017
Drafting Dep't.	10	.007				
Totals	136	.113	41	.026	1310	.859

Number of men in the first class	136
Number of men in the second class	41
Number of men in the third class	1310
Total	1487
Percentage of men in the first class	.113
Percentage of men in the second class	.026
Percentage of men in the third class	.859
Total[1]	.998

The majority of men employed by the P. and F. Corbin Company come under the third class specifications. Practically no work in the line of measurements is required of the men employed in this factory. The average man in the shop is a feeder to the machine. No knowledge of measurements is required.

The men falling in the first and second class are those who have been scientifically trained, either in a technical school or in the factory.

The making of the wrought and cast door knobs illustrate how little is expected of the workers in measurements. The stamping machines, millers, etc., are set by a trained man. These machines are checked regularly for accuracy by the inspector.

In comparing Table IV with Table XI, it is interesting to note the difference in the classification of men. The P. andF. Corbin tabulation is typical of the majority of New Britain industries. Measurements required of their men may be called crude in comparison to the Fafnir Ball Bearing Industry. 85 percent of the men employed in this factory need no knowledge of measurements; while 70 percent of the men employed in the bearing factory, needed to know how to use the finer types of measuring instruments.

1. Correct to April 1, 1931

The following table is a list of the different types of hardware manufactured by the P. and F. Corbin Company. The dimensions are those used in the manufacturing and selling of articles.

Table XII

Measurements Used In The Sale and Manufacturing of Hardware

1. Loose Pin Butts

Sizes	Weight per dozen pairs
a. $3\frac{1}{2}$ x $3\frac{1}{2}$ in.	$11\frac{1}{2}$ lbs.
b. 4 x 2 in.	16 lbs.
c. 6 x 6 in.	64 lbs.
d. 4 x 4 in.	21 lbs.

2. Heavy Cast Bronze Loose Pin Butts

Sizes	Weight per dozen pairs
a. 4 x 4 in.	$28\frac{1}{2}$ lbs.
b. $4\frac{1}{2}$ x $4\frac{1}{2}$ in.	26 lbs.
c. 5 x 3 in.	30 lbs.
d. 5 x $4\frac{1}{2}$ in.	52 lbs.

3. Loose Pin Templet Butts (For Metal Doors)

Sizes	Weight per dozen pairs
a. $3\frac{1}{2}$ x $3\frac{1}{2}$ in.	21 lbs.
b. 4 x 4 in.	36 lbs.
c. 5 x 4 in.	45 lbs.

4. Half Surface Loose Pin Butts

Size	Weight per dozen pairs
a. 5 x 5 in.	56 lbs.

Surface Flap 7/8 in. offset

5. Asylum Butts

Sizes	Weight per dozen pairs
a. $3\frac{1}{4}$ x $3\frac{1}{4}$ in.	21 lbs.
b. 4 x 4 in.	24 lbs.
c. 5 x 5 in	39 lbs.

6. Loose Joint Butts

Sizes	Weight per dozen pairs
a. $3\frac{1}{2}$ x $3\frac{1}{2}$ in.	14 lbs.
b. 4 x 4 in.	$17\frac{1}{4}$ lbs.
c. $1\frac{3}{4}$ x $1\frac{1}{4}$ in	$1\frac{1}{4}$ lbs.

7. Fast Joint Butts

Sizes	Weight per dozen pairs
a. 2 x $1\frac{1}{2}$ in.	15 oz.
b. $1\frac{1}{2}$ x $1\frac{1}{2}$ in.	13 Oz.
c. 5 x 5 in.	35 lbs.
d. 6 x 6 in.	56 lbs.

8. Shutter Butts

Sizes	Weight per dozen pairs
a. $1\frac{1}{2}$ x $1\frac{1}{2}$ in.	1 1/8 lbs.
b. $1\frac{1}{2}$ x 2 in.	1 3/8 lbs.
c. 2 x $1\frac{1}{2}$ in.	1 7/8 lbs.
d. 2 x 1 $\frac{3}{4}$ in.	2 1/8 lbs.

9. Wrought Brass Butts

sizes	Widths	Gauges	Weight per dozen pairs
a. $\frac{3}{4}$ in.	1 5/16 in.	.041	$2\frac{1}{4}$ lbs.
b. 1 in.	1 9/16 in.	.044	3 $\frac{3}{4}$ lbs.
c. $1\frac{1}{4}$ in.	1 $\frac{3}{4}$ in.	.045	$5\frac{1}{4}$ lbs.
d. $1\frac{1}{2}$ in.	2 in.	.105	2 lbs.
e. 2 in.	2 15/16 in.	.062	$9\frac{1}{2}$ lbs.

10. Display Case Butts with Pintles

Size	Weight per dozen pairs
a. 3 x $2\frac{1}{2}$ in.	$11\frac{1}{4}$ lbs.

11. Counter Hinges

Size	Weight per dozen pairs
a. 1 5/8 in. x 3 $\frac{1}{2}$ in.	$11\frac{1}{2}$ lbs.

12. Stop Butts

Sizes	Weight per dozen pairs
a. 1 x 2 in.	$11\frac{1}{4}$ lbs.

13. Screen Hinges

Sizes	Weight per dozen pairs
a. $1\frac{3}{4}$ x 1 1/8 in.	$2\frac{1}{2}$ lbs.
b. $1\frac{3}{4}$ x $1\frac{1}{4}$ in.	$2\frac{3}{4}$ lbs.
c. $1\frac{3}{4}$ x $1\frac{1}{2}$ in.	3 lbs.
d. 2 x 1 5/8 in.	4 $\frac{3}{4}$ lbs.

14. Pin Hinges

Sizes	Weight per dozen pairs
a. 2 in.	$1\frac{1}{4}$ lbs.
b. 3 in.	2 lbs.

15. Door Stops

Size	Width	Weight per dozen pairs
a. $1\frac{1}{2}$ x 1 7/8 in.	15/16 in.	$2\frac{1}{2}$ lbs.

16. Cabinet Bolts

Size	Weight per dozen
a. $2\frac{1}{2}$ in.	2 lbs.

17. Book Case Bolts

Sizes	Weight per dozen
a. 5/8 x $3\frac{1}{4}$ in.	$1\frac{1}{2}$ lbs.
b. 7/8 x 4 $\frac{3}{4}$ lb	6 lbs.

18. Flush Bolts

Size	Width	Weight per dozen
a. 3 in.	$\frac{3}{4}$ in.	2 lbs.
b. 4 in.	$\frac{3}{4}$ in.	6 lbs.

19. Extension Flush Bolts

Plate	Length	Weight per dozen
a. 5 7/8 x 5/8 in.	6 in.	6 lbs.
b. $6\frac{3}{4}$ x 1	30 in.	$8\frac{1}{4}$ lbs.

20. Mortise Extension Bolts

	Case	Backset	Knob
a.	$5\frac{1}{2}$ x 1 5/8 x 11/16 in.	1 in.	$2\frac{1}{4}$ in.
b.	$7\frac{3}{4}$ x 2 5/8 x 11/16 in.	2 in.	$2\frac{1}{4}$ in.

21. Cremone Bolts

	Case and Guide	Half Rod(round)	Weight
a.	$1\frac{1}{4}$ in.	$\frac{1}{2}$in.	$3\frac{1}{4}$ lbs.
b.	$1\frac{1}{2}$ in.	5/8 in.	6 lbs.
c.	$1\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$3\frac{1}{2}$ lbs.

22. Espagnolette Bolts (For hinged sash)

	Plates	Rods
a.	1 1/8 in.	3/8 in.
b.	1 $\frac{1}{4}$ in.	5/8 in.

23. Surface Door Bolts

	Guide	Round Rod	Width	Length	Weight
a.	1 5/8 in.	5/8 in.	5/8 in.	9 in.	16 oz/

24. Garage and Mill Door Bolts

	Plate	Length	Weight per dozen
a.	4 5/8 x 4 7/8 in.	9 in.	7 lbs.

25. Flush Sash Lifts

	Size	Weight
a.	5/8 x $1\frac{1}{2}$ in.	12 oz.
b.	5/8 x 1 3/8 in.	13 oz.
c.	$\frac{3}{4}$ x 15/8 in.	10 oz.

26. Sash Fasteners

	Case	Strike	Weight per doz.
a.	15/16 x 2 5/8 in.	5/8 x 2 3/8 in.	$2\frac{1}{2}$ lbs.
b.	1 1/16 x 3	5/8 x 3 in	4 $\frac{1}{2}$ lbs.

27. Casement Fasteners

	Plate	Lever	Projection	Weight
a.	3 3/8 x 1 1/8in.	3/8 in.	1 3/8 in.	8 lbs.

28. Casement Adjusters

Bar	Sash Plate	Sill Plate	Length
a. 5/16 in. diameter	5/8 x 2 in.	1 3/8 in.	12 in.

Weight

25 lbs.

29. Transom Lifters (For transoms hinged at the top and hung on the bottom)

a. Window Plate	Rod	Weight	Length
7/8 in.	$1\frac{1}{4}$ in.	15 oz.	3 in.

30. Sash Chains

	Gauge
a. No. 0	.028
b. No. 1	. 028
c. No. 2	.028

31. Coat and Hat Hooks

Base	Projection	Weight per doz.
a. $\frac{3}{4}$ x $1\frac{1}{2}$ in.	$3\frac{1}{4}$ in.	4 lbs.

32. Chandelier Hooks

Size	Weight per doz.
a. $2\frac{1}{2}$ in.	$3\frac{1}{4}$ lbs.

33. Drawer Pull

Size	Weight per doz.
a. $2\frac{1}{2}$ in.	4 lbs.

34. Automatic Exit Fixture (Exit Bars for use with lock)

Escutcheon	Horizontal Bar	Weight
a. $8\frac{1}{2}$ x $2\frac{1}{2}$ in.	$\frac{3}{4}$ in. tubing	$4\frac{1}{2}$ lbs.
b. 4 x $2\frac{1}{2}$ in.	" " "	" "

35. Reversible Automatic Fixtures

Horizontal Bar	Brackets
a. $\frac{3}{4}$ in. tubing	5 5/8 x 2 7/8 in.

36. Exit Bolts with Push Bars

	Bolt Rod	Horizontal Bar	Brackets
a.	9/16 in. dia.	3/4 in. tubing	5 5/8 x 2 7/8 in

Top Strike	Height of bar from floor
$\frac{1}{2}$ in.	39 inches

37. Lock Springs (Flat)

Width

a. 1/16 width

b. 3/32 in.

c. $\frac{1}{4}$ in.

38. Lock Spring Compression Gauge

a. .036

b. .022

c. .025

39. Thumb Knobs

	Plate	Cup	Weight per doz.
a.	4 x $3\frac{1}{2}$ in.	2 7/8 in.	9 lbs.
b.	8 x $3\frac{1}{2}$ in.	3 in.	$13\frac{1}{4}$ lbs.

40. Cylinders (Collars)

a. 2 inches

b. 2 x 2 in.

c. 2 $\frac{1}{4}$ x 2 $\frac{1}{4}$ in.

d. 1 7/8 in. x 1 7/8 in.

41. Support or Stop Hinges

	Size	Weight
a.	3 inches	$3\frac{1}{4}$ lbs.
b.	4 inches	$5\frac{1}{4}$ lbs.

42. Floor Spring Hinges

	Width	Length	Depth	Weight
a.	$4\frac{1}{2}$ inches	$8\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	$7\frac{1}{2}$ lbs.

43. Ball Bearing Pivots

Diameter	Depth	Shoe	Weight of doors	Weight
a. 2 in.	1 1/8 in.	5/8 x 3 in.	250 lbs.	$1\frac{1}{4}$ lbs.
b. 5 in.	2 $\frac{1}{4}$ in.	$1\frac{1}{2}$ x $7\frac{1}{4}$ in.	3000 "	$7\frac{3}{4}$ "

44. Lavatory Hinges

Size	Weight
a. $3\frac{1}{2}$ x 5 in.	$15\frac{3}{4}$ lbs.

45. Lavatory Spring Hinges

Size	Weight per doz. prs.
a. $3\frac{1}{2}$ in.	8 lbs.

46. Door Checks and Springs

	Weight
a. For screen doors	$6\frac{1}{4}$ lbs.
b. For doors between dinning room and butlers' pantry, car doors, or any inside door not over 7 x 3 ft.	$8\frac{1}{4}$ lbs.
c. For Vestibule Doors, heavy inside doors, such as are used in public buildings, stores, hotlels and railroad depots.	27 lbs.
d. For extra high doors and extra heavy doors, such as are used in public buildings, stores, hotels and raildroad depots.	32 lbs.

47. Lavatory Latches

Size	Length of bar	Weight
a. $2\frac{1}{2}$ in. dia.	4 inches	6 lbs.

48. Lavatory Door Bolts

Case	Backset	Weight
a. $2\frac{1}{2}$ x 5 5/8 in.	1 5/8 in.	12 lbs.

49. Foot and Bottom Bolts

Width	Length	Weight per doz.
a. 1 11/16 in.	3 in.	7 lbs.
b. 2 1/8 in.	$3\frac{1}{2}$ in.	$7\frac{1}{2}$ lbs.

50. Chain Bolts

Width	Length	Weight per doz.
a. 2 1/8 in.	4 in.	$7\frac{1}{2}$ lbs.
b. 2 1/8 in.	6 in.	13 lbs.

51. Spring Bolts

Length	Weight per doz.
a. 2 in.	9 oz.
b. $2\frac{1}{2}$ in.	14 oz.
c. 3 in.	1 lb.

52. Barrel Bolts

Size	Weight per doz.
a. 3 in.	$3\frac{1}{2}$ lbs.
b. 4 in.	4 lbs.
c. 5 in.	6 lbs.
d. 6 in.	$7\frac{1}{2}$ lbs.

53. Door Fasteners

Size	Weight per Doz.
a. $7\frac{1}{4}$ in.	9 lbs.
b. 4 in.	4 lbs.

54. Door Stops and Holders

Projection	Weight per Doz.
a. 5 in	21 lbs.
b. 6 in.	22 lbs.
c. 7 in.	23 lbs.

55. Door Holders

Size	Throw	Weight per doz.
a. $7\frac{3}{4}$ x 2 1/8 in.	1 3/8 in.	91 lbs.

56. Garage Door Holders

Size	Throw	Weight per doz.
a. $7\frac{3}{4}$ x 2 1/4	1 3/8 in.	91 lbs.

57. Store Door Thumb Latches

	Size	Weight
a.	$6\frac{1}{2}$ in.	$13\frac{1}{2}$ lbs.

58. Store Door Handled Lockset

	Size	Projection	Collar
a.	11 3/8 x $2\frac{1}{4}$ in.	2 7/8 in.	2 $\frac{3}{4}$ in.

59. Door Pulls

	Size	Weight
a.	7 $\frac{1}{2}$ in.	3 lbs.

60. Push Plates

	Size	Weight per doz.
a.	10 x 2 $\frac{3}{4}$ in.	$4\frac{1}{2}$ lbs.

61. Kick Plates

Sizes according to order. Always in feet and inches

62. Push Bars

	Base	Bar	Length	Projection	Clearance	Weight
a.	$2\frac{3}{4}$ in.	1 in.	24 in.	3 in.	1 5/8 in.	$4\frac{1}{2}$ lbs.

63. Studs and Rosettes (Round Top)

	Size	Projection	Weight per Gross
a.	$\frac{1}{2}$ in. Dia.	$\frac{1}{4}$ in.	$3\frac{1}{2}$ lbs.

64. Hinge Plates

	Corner	Center
a.	16 x $27\frac{3}{4}$ in.	17 7/8 x 25 $\frac{1}{4}$ in.

65. Three Point Lock (For Metal Doors)

a. Unit Plate 6ft. x $4\frac{1}{2}$ ft. x 1 3/8 ft.

Center and Bottom Dead Bolt $\frac{3}{4}$ in. in diameter $\frac{3}{4}$ in. throw

Top dead bolt, with anti friction roller 3/5 in. in diameter 3/4 inch throw

Center of top bolt to center of bolt 27 inches

Center of bolt to center of bottom bolt 26 inches

Center of center bolt to center of latch bolt $7\frac{1}{2}$ inches

66. Lock

Iron Case	Backset	Spacing	Front
a. 5 7/8 in.	3 in.	3 3/8 in.	$8\frac{3}{4}$ x $1\frac{3}{4}$ in.

67. Druggist Drawer Pulls

	Opening	Weight
a. Size $2\frac{1}{2}$ inches	5/8 x $1\frac{3}{4}$ in.	$1\frac{1}{4}$ lbs.

68. Electric Push Buttons

Diameter	Weight
a. $3\frac{3}{4}$ in.	$1\frac{1}{4}$ lbs.

69. Door Knockers

Size	Weight
a. 3 7/8 x 1 $\frac{1}{4}$ in.	$5\frac{1}{2}$ oz.
b. 4 x $2\frac{1}{4}$ in.	6 oz.
c. 4 1/8 x 1 1/4 in.	5 oz.

70. Letters A.B.C.D.E. etc.

Size

Varying from $\frac{1}{4}$ in to $6\frac{1}{2}$ inches

71. Name Plates

Size	Weigth, each
a. 3 x 5 in.	8 oz.
b. 3 x 11 in.	1 1/8 lbs.

72. Sash Rollers

Case	Wheel	Weight, Gross	Weight, Dozen
a. 5/8 x $1\frac{1}{4}$ in.	5/8 in.	7 $\frac{1}{2}$ lbs.	14 oz.
b. 3/4 x 1 5/8 in.	5/8 in.	10 3/8 lbs.	16 oz.

73. Side Pulleys

Diameter of Wheel	Weight per dozen
a. 3/4 in.	1 1/4 lbs.
b. 2 in.	10 1/2 lbs.

74. Sash Pulleys

Wheel Diameter	Front	Weight per dozen
a. 2 in.	$4\frac{1}{2}$ x 1 1/16 in.	$6\frac{1}{2}$ lbs.

b.	$2\frac{1}{2}$ in.	$5\frac{1}{2}$ x 1 1/8 in.	$10\frac{1}{4}$ lbs.

75. Screw Pulleys

	Size, diameter	Weight per dozen
a.	3/4 in.	13 oz.

Table XIII

Units of Measurements Occurring in Table XII[1]

	Inch	Pound	Dozen	Pairs	Ounce	Gross	Foot
1.	8	4	4	4			
2.	8	4	4	4			
3.	6	3	3	3			
4.	3	1	1	1			
5.	6	3	1	1			
6.	6	3	3	3			
7.	8	2	4	4	2		
8.	8	4	4	4			
9.	10	5	5	5			
10.	2	1	1	1			
11.	2	1	1	1			
12.	2	1	1	1			
13.	8	4	4	4			
14.	2	2	2	2			
15.	3	1	1	1			
16.	1	1	1				
17.	4	2	2				
18.	4	2	2				
19.	6	2	2				
20.	10						
21.	6	3					
22.	4						
23.	4				1		
24.	3	1	1				
25.	6				3		
26.	8	2	2				
27.	4	1					
28.	5	1					
29.	3				1		
30.	0	0	0	0	0		
31.	3	1	1				
32.	1	1	1				
33.	1	1	1				
34.	6	1					
35.	3						
36.	5						
37.	3						
38.	0	0	0	0	0		
39.	6	2	2				
40.	7						
41.	2	2					
42.	3	1					
43.	8	4					

Numbers 1-75 represent articles listed in Table XII

	Inch	Pound	Dozen	Pairs	Ounce	Gross	Foot
44.	2	1					
45.	1	1	1	1			
46. a.	1						
b.	1						
c.	1						
d.	1						
47.	2	1					
48.	3	1					
49.	4	2	2				
50.	4	2	2				
51.	3	2	2		2		
52.	4	4	4				
53.	2	2	2				
54.	3	3	3				
55.	3	1	1				
56.	3	1	1				
57.	1	1					
58.	4						
59.	1	1					
60.	2	1					
61.	0						
62.	5	1					
63.	2	1				1	
64.	4						
65.	7						3
66.	5						
67.	3	1					
68.	1	1					
69.	6				3		
70.	0						
71.	2	1			1		
72.	6	2	2	2		2	
74.	6	2	2				
75.	1		1		1		
Totals	292	100	77	42	14	3	3

Table XIV

Frequency of Different Units of Measurements Used In the Manufacturing and Selling of Seventy Five Listed Articles

1. Inch	292
2. Pound	100
3. Dozen	77
4. Pair	42
5. Ounce	14
6. Gross	3
7. Foot	3

Table XIV shows a different set of units than was used by the Fafnir Ball Bearing Company. (See Table VI) The inch and the pound are the most common units of measurements used in this factory. The gross is not used in the manufacturing of the small hinges. These are automatically counted by a machine.

Conclusion

Total number of different tables of denominate numbers used in the P. and F. Corbin Hardware Company.

A. Purchasing of Materials

- Avoirdupois
- Unit
- Linear
- Liquid
- Board
- Metric Weight
- Paper

B. Manufacturing and Selling of Hardware

- Linear
- Avoirdupois
- Unit

C. Number of Tables of Denominate Numbers 7

A check up with items listed in Tables IX and XIII with that of Table VII, shows that seven of the tables listed in VII are used by the P. and F. Corbin Company. Never is a table of denominate numbers used in its entirety.

In comparing the tables used in purchasing materials with that of the Fafnir Ball Bearing Company, it is interesting to note that the measurements are somewhat the same, Fafnir using two more tables, namely the Cubic and the Board.

Seldom are more than two units used from each table.

The following shows the different units used in the pur-purchasing, manufacturing and selling of articles by the P. and F. Corbin Company.

A. Purchasing

1. Avoirdupois 3 units

Ton for metals

Pound for rubber, white lead, nickels, etc.

Hundredweight for rolls of paper

2. Unit 1 unit

Unit for purchasing measuring instruments

3. Linear 1 unit

Foot for length

4. Liquid 1 unit

Gallons for capacity

5. Board 1 unit

Board Foot for length, width and thickness

6. Metric-Weight 1 unit

Kilogram for weights of foreign chemicals

7. Paper 1 unit

Quire or quantity

B. Manufacturing and Selling

1. Linear 2 units

Inch for width and length

Foot for length and width for three point locks

2. Avoirdupois 2 units

Ounce for weights of small bolts

Pound for weights of the larger hardware

3. Unit 3 units

continued-

Dozen used in determining the weight of 12 articles. Small hardware usually sold by the dozen or dozen pairs.

Gross for the number of hinges that will fill a small keg.

Only 12 units out of the possible 67 listed in Table VII are used by the P. and F. Corbin Company.

In comparing this industry with the ball bearing company, a great difference may be seen in the measurements used in the manufacturing and selling of articles. The P. and f. Corbin factory is a typical New Britain industry, in that no knowledge of measurements is required of the men to say nothing of a knowledge of finer measurements used in determining accuracy. The majority of men employed in this factory are machine feeders. These machines are continually checked by experts in the factory. These experts are only ones who need a knowledge of measurements whatsoever, and being experts they of course understand the use of the finer measurements.

The Stanley Rule and Level Company

In 1858, A. Stanley & Company and Hall & Knapp were consolidated under the articles of incorporation of the latter company, under the name of the Stanley Rule and Level Company.

A few years later, they bought the handle business carried on by Mr. John Stanley. This business was large, and all the hickory which could be obtained within a radius of about fifty miles, was bought. Finally, the supply of hickory being practically exhausted, the special lathes for turning the handles were sent to Greensboro, N.C., where the handles were roughed out to shape and sent to New Britain for finishing.

In the years from 1865 to 1880, many special articles were made, such as caster wheels, furniture knobs and door handles. For several years they quantities of earrings, breast pins and sleeve buttoms from boxwood and vegetable ivory.

In 1889, the company purchased the plane business of a Boston concern, removing the works to New Britain. This has since constituted one of the most important parts of their business. To the original small list of carpenter's tools manufactured, many important additions have been made, including planes, miter boxes, bit braces, breast drills, hammers, chisels, screw drivers, vises, steel squares, gauges, etc. The business has had a rapid growth. Today, the company is the largest in the world devoted exclusively to the manufacture of carpenter's tools, and its specialties are sold throughout the world.

The following table will show the most important materials that the Stanley Rule and Level Company purchases for the manufacturing of the different tools and in running the factory.

Table XV

Measurements Used In Purchasing

Name of Materials	Measurements
1. Coal	Gross Ton
2. Steel	Ton
3. Brass	Ton
4. Screws	Gross
5. Pig Iron	Ton
6. Chemicals	Pound and Gallon
7. " (Foreign)	Kilogram
8. Sand	Cubic Yard
9. Glass Tubes	Inch(Length and Width)
10. Wrought Iron Sheets	Foot and Inch
11. Oils	Barrels (Gallon)
12. Stains	" "
13. Alcohol	" "
14. Wood	Board Foot
15. Belting	Foot and Inch
16. Waste, etc.	Pound
17. Wire	Foot and Pound
18. Cables	Foot and Pound
19. Paper(Wrapping, etc.)	Hundredweight and Inch
20. " (Office)	Quire
21. Nails	Keg
22. Factory Chalk	Gross
23. Talc	Pound
24. Grease	Pound
25. Tar	Pound
26. Glycerine	Pound
27. Instruments	Unit

Table XVI

Summary

Common Measurements Used In Purchasing Materials

Unit	Frequency	Unit	Frequency
1. Pound	8	8. Cubic Yard	1
2. Gallon	8	9. Kilogram	1
3. Foot	4	10. Board Foot	1
4. Inches	4	11. Quire	1
5. Ton	3	12. Unit	1
6. Gross Ton	1	13. Hundredweight	1
7. Gross	1		

The Making of the Wood Level

The making of the wood level is relatively a simple process. Large pieces of wood usually measuring 20'x 6" x 3" are cut into sections of 18" x 2" x 2". In making this particular section, the machine is set so that no measurements need to be used in cutting out the pieces of wood.

After the rectangular block has been cut, it is placed through two planers, which gives it a very smooth finish. It is then placed upon the drill and cutting table where the bed of the glass guage is cut out. From here, it is sent to the painting department where it is sprayed with an oil and varnish stain combination.

The adjustable level has the level glass set in plaster in a metal case. The case is fastened to a steel base on one end by a screw and bushing and on the other adjusting end by a special spring and adjusting screw. The case completed is fastened securely in the level by two wood screws. The top plate is independent of the level cases, thus permitting the level

to be easily adjusted.

In making the level no knowledge of measurement is required by the worker. The plans are drawn by the draftsman; the machines are set by the inspector and the cutting of wood is done by the carpenter. One trained man does the setting of the glass plumbs. Most of the men in this department are machine feeders.

The majority of men in the factory come under the third class specification.

In the entire process of making the level, the men have to be skilfull in adjusting certain parts. This, however, requires no knowledge of measurements.

The following table will show the number of men employed who need to know measurements in the Stanley Rule and Level Company.

Table XVII

The Number of Men Employed Who Need to Know Various Degrees of Accuracy in the Manufacturing of the Rules and Levels[1]

Employes[2]	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Tool Makers	9	.02				
Machine Setters	12	.03				
Model Makers	5	.01	6	.01		
Die Makers	5	.01				
Machinist	20	.04				
Foremen	20.	.04	15	.04		
Tinsmith	1	.002	1	.002		
Maintenance Dep't.			3	.009		
Millwrights			3	.009		

1. The following data were given by the Plant Superintendent
2. According to specifications above Table IV

continued

Employes	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Pattern Makers (wood)			1	.002		
" " (metal)	5	.01				
Machine Designers	1	.002				
Draftsmen	4	.009				
Inspectors	3	.009	4	.009		
Automatic Machine O'rs.	8	.02				
Pressmen					5	.01
Wood Turners					2	.005
Machine Operators					73	.16
" " (heavy)					38	.09
Bench Operators					22	.05
Tempers					10	.02
Polishers (Wheek and Bekt)					50	.10
Wheel and Belt Setters					5	.01
Platers					10	.02
Buffers					6	.01
Assemblers					6	.01
Packers					23	.05
Shipping Laborers					19	.04
Truckers					2	.005
Factory Truckers					12	.03
Yard Men					13	.03
Sweepers					9	.02
Firemen and Coal Passers					4	.009
Carpenters			2	.005		
Electrician			2	.005		

continued-

Employes	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Watchmen					18	.04
Totals	92	.192	37	.091	327	.079

Number of men in the first class	92
Number of men in the second class	37
Number of men in the third class	327
Total	456[1]

Percentage of men in the first class	.192
Percentage of men in the second class	.091
Percentage of men in the third class	.709
Total	.992

The tabulations above are somewhat similar to the tabulations under the P. and F. Corbin Company. A large percentage of the men employed by both companies come under the third class specifications. The work in this factory does not require a minute degree of accuracy on the part of the men working in the factory. Most tools manufactured are accurate to .001, wood levels, etc. to .01.

Tolerances used by the Stanley Rule and Level Company are practically the same as those used by the P. and F. Corbin Company. There are generally what is known as three classes of tolerances in the manufacturing of tools and hardware. The first is the "specially close dimension" which is usually plus or minus .001. The second class is the "less particular to the plan" and is usually plus or minus .003. "The general class" as called by both factories, is plus or minus .005. These

tolerances are always designated on the draftsman's prints.

The followin g is a list of the most important articles kept in stock. The measurements used in the selling and manufact ring of the different tools are tabulated.

Table XVIII

1. Boxwood Rules

Graduated in eighths and sixteenths

Two feet long

One and three eighths inches wide

2. Boxwood Caliper Rules

These calipers rules have the clipper or caliper slide made of brass and machined accurately to fit the "T" slot at the leg of the rule. The slides are graduated in 16ths and 32nds of an inch.

3. Shrinkage Rules

All castings shrink in cooling, depending on the kind of metal, the thickness and the conditions under which cast. The shrinkage per foot of casting where the thickness runs about one inch cast under ordinary conditiOns is shown in the table.

Cast Iron	1/8 in.
Brass	3/16 in.
Steel	1/4 in.
Zinc	5/16 "
Tin	1/13 "

2 feet long

$1\frac{1}{2}$ inches wide

4. The Extension Rules

The rules are valuable in measuring accurately the distance between two fixed points. When extended to a

required length, the section may be secured by a set screw.

Length 2 to 4 feet

Graduated in 8ths of an inch

5. Wood Plumbs and Levels

The adjustable levels have the level glass set in the plaster of a metal case. This case is fastened to a steel base on one end by a screw and bushing and on the other side by a special spring and adjusting screw. The plumb glass is an adjustable level, set in a cast flanged in at one side, and is secured to a specially formed cap so made that there is leeway for rotating the flange case for proper adjustment. All measurements used in the selling of the plumb and rule levels are in inches. Sizes vary from 10 to 48 inches.

6. The Machinist Levels

The bottom of these are milled true on both the smooth and grooved patterns. They are fitted with ground glass which are extra long and of large pattern diameter. This makes them extremely sensitive thus adapted for machinist use.

Length 4 to 10 inches

7. Try and Mitre Squares

The edges of the blades are machined and are square inside and out. Regularly graduated in 8 ths of an inch. Metric graduations are used when so ordered.

Length 2 inches Handle length 2 7/8 inches

8. Steel Squares

Body	Tongue
24 x 2 in.	18 x $1\frac{1}{2}$ in.

9. Marking Gauges

The bars in all numbers are ovals in form and are graduated in 16ths of an inch.

Length $17\frac{1}{2}$ inches

10. Adjustable Iron Planes

Smooth	Cutter
$5\frac{1}{2}$ inches	$1\frac{1}{4}$ inches

11. Self Setting Iron Planes

Smooth	Cutter
$8\frac{3}{4}$ in.	$1\frac{3}{4}$ in.

12. Block Planes

6 inches long	1 3/8 in. cutter

13. Matching Plane

Cuts 1/8 in. grooves on boards 3/8 in. to $\frac{1}{2}$ in.

Has a center of 3/8 in.

14. Skew Cutter Combination

$10\frac{1}{2}$ inches long

Plow and Dado, 3/16, $\frac{1}{4}$, $\frac{1}{2}$, 5/8 in.

Fillester $1\frac{1}{2}$ inches

Tonguing $\frac{1}{4}$ in.

15. Scraper Planes

$6\frac{1}{4}$ inches long

$2\frac{1}{2}$ inch blade

16. Scrapers

11 inches long

$2\frac{1}{2}$ inch blade

17. Hammers

13 ounces	13 inches overall

18. Riveting Hammers

4 ounces	11 inches overall

19. Ripping Chisels

$\frac{3}{4}$ in. stock	1 5/8 in. cutting edge

18 inches long

20. Floor and Clapboard Chizel

$\frac{3}{4}$ in. Stock	2 in. cutting edge

18 inches long

21. Miter Boxes

20 x 40 inches Capacity Right Angles $8\frac{1}{4}$ in.

Capacity Miter (45 degrees) $5\frac{1}{4}$ inches

" at 30 degrees without stock guide $3\frac{1}{2}$ inches

Weight 18 pounds

22. Screw Drivers

The blade, shank and head are formed from one piece of steel. The shank passes through the handle and the ferrule is pinned. The head has two projecting wings, which together with the pins keep the shank from turning the handle.

Blade $2\frac{1}{2}$ inches overall Diameter 7/32 in.

$2\frac{1}{2}$ inch blade

23. Awls

Diameter of point 1/16 in.

Overall 4 $\frac{3}{4}$ inches

24. Hand Axe

18 inches overall $2\frac{1}{4}$ lbs. without handle

25. Portable Electric Drill

Capacity 5/16 inches in steel

" 5/8 inches in hard wood

" 1 inch in soft wood

Chuck Speed 1,100 R. P.M.

Full Load 600 R.P.M.

Length over all 13 inches

Net weight $8\frac{1}{4}$ lbs.

Shipping Weight 13 lbs.

26. Rabbet and Rabbet Fillisters

These tools have two seats for the cutter, one for regular and the other for nos work. Also a spur and removable depth gauge. The adjustable fence can be used on either side of the plane and slide under the bottom for regulating the width of the cut. The rear cutter is adjustable endwise.

a. $8\frac{1}{2}$ inches long

$1\frac{1}{2}$ inch cutter

Weight $2\frac{3}{4}$ lbs.

b. $8\frac{1}{2}$ inches long

$1\frac{1}{2}$ inches for cutter

Weight $1\frac{1}{4}$ lbs.

27. Rabbet and Dado Planes

Handled Iron Rabbet Planes

a. 8 in. long $1\frac{1}{2}$ inch cutter

b. 8 in. long $1\frac{1}{4}$ inch cutter

c. 8 inches long 1 inch cutter

Corner Rounding Planes

a. $7\frac{1}{2}$ inches long $\frac{1}{2}$ inch cutter

b. $7\frac{1}{2}$ inch long $\frac{1}{4}$ inch cutter

c. $7\frac{1}{2}$ inches long 3/8 inch cutter

28. Miscellaneous Planes Router Plane

This is a small plane which is used on a very narrow piece of work for cabinet and pattern makers in letting in the lock plates.

3 inches long $\frac{1}{4}$ inch cutter

29. Cabinet Makers Rabbet Planes

Used in fine cabinet work where extreme accuracy is required. Both sides of these planes are square with the bottom.

30. Bevel and Angle Tools

These bevels ahave a locking device which prevents the blades from slipping. Blades are "machined" and ground on both sides and edges.

a. Rosewood handles

6 inch blade $4\frac{1}{2}$ inch handle

b. Iron handle

6 inch blade $4\frac{1}{4}$ inch handle

c. Iron Handle

12 inch blade 6¼ inch handle

31. Special Gauges

These gauges are mainly used for marking door panels and such wide work where an extra long bar is needed. They have an extra wide head that is rabbeted to prevent slipping.

a. 17½ inches long

b. 20¼ inches long

32. Butt Gauges

Graduated in 16ths of an inch for two inches

Graduated in 16ths of an inch for three inches

33. Hollow Handle Tool Sets

Eight tools are furnished, 1 each: Gimlet, File, Saw, Chizel, Reamer, Screw Driver, and two Brad Awls. The tools are approximately 4 inches long.

a. Cocobolo Handle, 7 3/8 inches long

b. Hardwood Stained, 7 3/8 inches long

34. Latch Pawl Ratchet

a. 8 inch sweep

b. 10 inch sweep Jaws sold by the pairs

c. 11 inch sweep

35. Corner Bit Braces

a. 8 inch sweep

b. 10 inch sweep Jaws sold by the pairs

36. Ratchet Bit Braces

The jaws are sold by the pair

The braces are sold by the sweep. Sweeps vary from 8 inches to 16 inches.

37. Breast Drills

The frame is in one piece, made of malleable iron, all jaws are forgings, machined and hardened.

$\frac{1}{2}$ inch to 1/8 inch in diameter. This measurement is the size of the shank that the jaw will take.

38. Bit Brace Tools

Tip	Length
3/16 inch	$4\frac{1}{2}$ icnh

39. Hand Drills

The frames are malleable iron or steel. These have parallel sides, providing a handl means of attaching the drill frame. All gears are machined, that is cut.

Speed Gear $\frac{3}{4}$ in.

Chuck $\frac{1}{4}$ inch

Drill Bits 1/16 inch

40. The Bench Plane

A smooth plane is used for finishing or smoothing off flat surfaces where uneven spots are of slight area. Its short length will permit it to locate these irrelularities, leaving it with a smooth surface.

10 inches long

2 inch cutter

41. The Spoke Shave

a. Adjustable Cutter

10 inches long 2 1/8 inch cutter

42. Double Iron Spoke Shave

10 inches long 2 1/8 in. cutter

43. Spoke Shave, Two Cutter

10 inches long $1\frac{1}{2}$ inch cutter

44. Spoke Shave, Adjustable Mouth

10 inches long 2 1/8 inch cutter

45. Riveting Hammers

a. 4 ounce	4 inch overall
b. 7 ounce	12 " "
c. 12 ounces	13 " "

d. 18 ounces 14 inches overall

46. Tinners Rivetting

12 ounces 13 inches overall

47. Tinners Paneing Hammers

a. 8 ounces 12 inches overall

b. 12 ounces 13 inches overall

c. 16 ounces 14 inches overall

48. Farrier Hammers

a. 7 ounces 13 inches overall

b. 10 ounces 14 ounces overall

49. Bricklayer Hammers

a. 24 ounces 11 inches overall

b. 32 ounces 11 " "

50. Machinist Hammers

a. 4 ounces 10 7/8 inches overall

b. 14 ounces 14 ½ inches overall

51. Engineer Hammers

a. 18 ounces 14 inch overall

b. 22 ounces 16 " "

52. Tongue Cutting Chisels

a. ½ inch stock	7 inches long	2 inch bit
b. 5/8 inch "	8 " "	2½ " "
c. 3/4 " "	9 " "	3 " "

53. Offset Cutting Chisels

5/8 inch stock 11 inches long 2½ icnh bit

54. Nail Cutting Chisels

5/8 inch stock 11 inches long 2½ icnh bit

55. Bevel Edge Butt

a. 1/8 inch blade 8 inches overall

b. ¼ onch 8 inch overall

56. Square Edge Firmer

Blade 4½ inches 11¼ icnh overall

57. Socket Chisels

a. 1/8 inch blade	8 1/8 inch overall
b. 1 " "	$8\frac{1}{2}$ " "
c. 2 " "	$9\frac{1}{4}$ " "

58. Socket Chisels In Sets

Length $4\frac{1}{2}$ inches

Size of chisels $\frac{1}{4}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 inch

59. Glazier Chisels

2 inch blade	9 inches overall

60. The Shoot Board and Plane

The swivel can be locked at any angle between zero an 90 degrees.

Length 22 inches Palne 15 inches

Cutter 2 3/8 inches

61. The Side Rabbet Plane

These are used in trimming dados, mouldings and gooves of all kinds.

a. 4 inches long	$\frac{1}{2}$ inch cutter
b. 4 " "	$\frac{1}{2}$ " "

62. Cabinet Makers Block Plane

Used bu piano makers and workmen in kindred trades who require an extra fine tool for finishing hardwoods.

a. 10 inches long	2 inch cutter
b. 1o inches long	2 $\frac{1}{2}$ icnh cutter

63. Core Box Plane

This plane is designed for making circular core boxes. The sides of the plane are at right angles. The point of the plane will always cut on the circumference of the circle when the sides rest on the edges of the cuts.

a. To work in semi-circles	5 to 7 inches long
b. " " " " "	$7\frac{1}{2}$ to 10 " "

64. Adjustable Chamfer Plane

This plane is for chamfer or stop chamfer work. It has ninety degrees V bottom which serves as a mitre guide.

9 inches long 1 5/8 inch cutter

Weight 3 3/8 lbs.

65. Cabinet Makers Edge Plane

a. 10 inches long $2\frac{1}{4}$ inch cutter

b. 12 inches long 3 inch cutter

Table XIX

Units of Measurements Occurring in Table XVIII

Article No.	Inch	Foot	Ounce	Angles	Pound	Pairs
1.	1	1				
2.	1					
3.	6	1				
4.	1	1				
5.	1					
6.	1					
7.	2					
8.	4					
9.	2					
10.	2					
11.	2					
12.	2					
13.	4					
14.	7					
15.	2					
16.	2					
17.	1		1			
18.	1		1			
19.	3					
20.	3					
21.	4			2		
22.	3					
23.	2					
24.	1				1	
25.	4				2	
26.	a.2				1	
	b.2				1	
27.	a.6					
	b.6					
28.	2					
29.	0					
30.	a.2					
	b.2					
	c.2					
31.	2					
32.	2					
33.	a.1					
	b.1					

Article No.		Inch	Foot	Ounce	Angles	Pound	Pairs
34.	a.	1					1
	b.	1					1
	c.	1					1
35.	a.	1					1
	b.	1					1
36.		1					1
37.		1					
38.		2					
39.		3					
40.		2					
41.		2					
42.		2					
43.		2					
44.		2					
45.		4		4			
46.		1		1			
47.		1		1			
48.		2		2			
49.		2		2			
50.		2		2			
51.		2		2			
52.		9					
53.		3					
54.		3					
55.		4					
56.		2					
57.		6					
58.		6					
59.		2					
60.		3			1		
61.		4					
62.		4					
63.		2					
64.		2			1	1	
65.		4					
	Totals	182	3	16	4	6	6

Table XX

Frequency of Different Units of Measurements Used In the Manufacturing and Selling of the Sixty-Five Listed Articles

1. Inch	182
2. Ounce	16
3. Pound	6
4. Pair	6
5. Angles	4
6. Foot	3

Table XX shows a greater frequency in the inch than in any other unit used in the Stanley Rule and Level Company. Table XIV of the P. and F. Corbin Company, shows that the inch is the most common unit of measurement used in the manufacturing and selling of the different articles. The highest frequency in both companies occurring in the inch. In comparing the units used in these two companies we find the P. and F. Corbin Company using two different units not used by the Rule and Level Company, namely the "dozen" and the "gross". The Rule and Level Company uses one unit which is not used by any other company in this study, that being the "angle".

Conclusion

Total Number of Different Tables of Denominate Numbers Used in the P. and F. Corbin Company.

A. Purchasing of Materials

Advoirdupois

Unit

Liquid

Metric-Weight

Cubic

Linear

Board Foot

Paper

B. Manufacturing and Selling of Tools

Linear

Advoirdupois

Unit

Angles

In comparing the table of P. and F. Corbin (TableXIV) with that of the Stanley Rule and Level Company (Table XX)

one will find that the angle is used by the Stanley Rule and Level Company. This being the only difference in the measuremen used in the manufacturing and selling of articles.

The following shows the different tables of denominate numbers used in the purchasing, manufacturing and selling of the various articles.

A. Purchasing 1. Avoirdupois 3 units

Gross Ton

Ton

Hundredweight

The gross ton is used as a unit in the purchasing of coal. The ton is used in purchasing brass and steel. The hundredweight is used in the purchasing of rolls of heavy paper, the width of paper is ordered in inches.

2. Unit 1 unit

Unit

The unit is used in the purchasing of instruments as the vernier caliper and the micrometer.

3. Linear 2 units

Inch

Foot

The wrought iron sheets purchased from the Stanley Works of New Britain are purchased by the foot and inch. The foot used for length and the inch for breadth. The gauge for thickness of wrought iron sheets is included, this varies from .01 to .001 of an inch.

4. Liquid 1 unit

Gallon

The gallons are used as a unit of measurement in the purchasing of chemicals. Copper Sulphate and acids are purchased from some concerns by the gallons, while others sell acids by the pound.

5. Board 1 unit

a. Board Foot

In ordering wood for boxes and floorings, the width, length and thickness of boards are given.

6. Metric-Weight 1 unit

a. Kilogram

The kilogram is used in the purchasing of powdered chemicals from European countries.

7. Quire 1 unit

a. Quire

The quire is the unit of measurement used in purchasing all stationery used in the offices.

B. Measurements Used in Manufacturing and Selling

1. Linear 2 units

Inch

Foot

The inch is only unit of measurement used in the manufacturing of tools with the exception of rulers. In making the rulers the foot is used. In selling the tools the inch is the common unit used, the foot also being used in the sale of boxwood rules and boxwood caliper rules.

2. Avoirdupois 2 units

Ounce

Pound

The ounce is used in the sale of the various types of hammer heads. It is not used in the actual making of the hammer. The pound also is used in the sale of axes. The axe and the hammer heads are cast and no knowledge of these units are required of the men.

3. Unit 1 unit

Unit

The unit is used in the selling of parts of different tools as the plane and level.

4. Angles 1 unit

Right Angle

Used in the sale of the Shoot Board and Plane where the swivel can be locked at any angle between zero and 90 degrees

Number of different units used by the Stanley Rule and Level Company in the purchasing, selling, and manufacturing of articles.

1. Purchasing	10 units
2. Manufacturing and Selling	6 "
Total	16 units

According to the Plant Superintendent, the inch is the unit of measurements used in the manufacturing of all their tools.

The measurements used in this company are almost identical with those used by the P. and F. Corbin Company. In no case does either factory use an entire table of denominate numbers, only one and two units are used from the tables listed above.

The majority of men employed in this factory need no knowledge of measurements. The machines are set by and inspector or foreman and all that is required of the workman is to feed an automatic machine.

The unit, angle, pound and ounce are units used in the sale of rules and levels. The inch and foot are used in the manufacturing and selling of tools.

The Vulcan Iron Works

The Vulcan Iron Works was established in 1878. The original foundry was a round building which is now occupied by the annealing department. One furnace was operated with a cupola in an adjoining wooden building.

In 1883 another foundry was added, in which was installed a new cupola for malleable iron. At the same time the old cupola was used for melting grey iron. After three years the grey iron was discontinued, and an air furnace was installed for the making of malleable iron.

In 1913, the Eastern Malleable Iron Company was formed and the Culcan Iron Works are now one of the five plants owned and operated by the Eastern Malleable Iron Company.

The following line of castings are manufactured by the Vulcan Iron Works.

Builders' Hardware	Automobile Castings
Small Tool Castings	Belt Hooks
Agricultural Implements	Awning Hardware
Railway and Mine Supplies	Marine Hardware
Textile Machinery Castings	Piano Castings
Tobacco Press Work	Typewriter Castings
Naval Construction Work	Gymnasium Hardware
Fire Arms	Plumbing Supplies

Motorcycle and Bicycle Castings

The following table shows a list of the most important materials purchased in the making of the molds and castings.

Table XXI

1. Coal	Gross Ton
2. Sand	Cubic Yard

continued--

3. Plaster of Paris	Bags (Pound)
4. Wire	Hundredweight
5. Nails	Keg (Pound)
6. Coke	Ton
7. Acids	Pound
8. Bases	Pound
9. Core Sand	Hundredweight
10. Iron	Ton
11. Copper	Ton
12. Manganese	Pound
13. Brass	Hundredweight
14. Sulphur	Pound
15. Fire Brick	Per Thousand
16. Green Sand	Ton
17. Wood	Board Foot
18. Clay (Powdered)	Barrel (Pound)
19. Paints	Barrels (Gallon)
20. Oils	Gallon
21. Greases	Pound
22. Leather	Foot and Inch
23. Talc Pencils	Gross

Summary

Common Measurements Used In the Purchasing of Materials

Unit	Frequency	Unit	Frequency
1. Pound	7	5. Gross Ton	1
2. Ton	5	6. Cubic Yard	1
3. Hundredweight	3	7. Board Foot	1
4. Gallon	2	8. Gross	1

In all foundry work, the mold is the important factor. A mold is a form of refractory material such as sand or loam

into which the molten steel is run or poured. This determines the final shape of the poured metal after cooling.

While molds are made from many different materials, the shapes and methods are practically all alike. They are made from a pattern which is usually of wood or metal, except for the largest molds which are embedded in the floor of the foundry. These molds are inclosed in a "flask", which may be of either wood or metal, rigid or hinged. These molds are formed in a material which will withstand the heat of the molten metal when it is poured.

The most common materials used in the Vulcan Iron Works in their mold work are; sand, either dry or green, loam, plaster of paris, and iron. The iron being used in "chilled" work as in the making of carwheels. The cavities in the castings are formed by means of a core, which may be either a baked core or a green sand core.

The molding operations are variously subdivided. There is what is known as bench work, usually for the lighter class of castings. The floor work is for heavier type of castings. The work is sometimes classified according to the materials of which the mold is composed, such as dry sand, loam and "chilled " work. Another classification is the hand and machine work, depending on whether the mold is made by hand or on a molding machine.

The Making of a Wheel And Pulley

In the larger sizes of wheels, provisions are made for pouring the rim and hub separately. The mold is made up with the rim and hub pattern in the usual manner, after the mold has been opened and the pattern withdrawn, the wrought iron spokes are set in shape. The end of the spokes which are to come in contact with the hot metal are painted with a mixture of

red lead and gasoline. The rim is first poured and in shrinking forces the spokes inward. After the rim is cooled, the hub is poured. According to the foreman of the plant, wheels of this character are made weighing six tons and up to ten feet in diameter. It is a common practice to cast iron around iron or steel shafts. If the shafts should be given a coating of liquid glass prior to being placed in the mold, the iron will lie quietly against this, and when cold, a pressure of many pounds will be necessary to separate the two. In most cases aluminum is used.

In making pulleys, the work is ordinarily done on a machine which will take a pattern up to six feet in diameter. Many of the patterns in this factory are still molded by hand. In making the pulley the pattern includes a rim, arm loose in rim and a loose hub. In molding, the rim is rammed up into a "cheek" which is part of the "flask"stacked on the floor. After the sand is rammed inside to the required depth and a hole dug at the center, it is then rammed around the outside of the rim. The arms are then laced inside the rims and sand is tucked under them and around the hub and joint. After the ramming, the pattern is drawn and the "cheek" lifted. The rim is finished and the cope and drag halves of the center is marked so that they can be replaced. The upper half of the center is lifted off, the hub drawn, and the arms drawn from the drag with the hub. The rim is then blackened, and rings half to three quarters of an inch in thickness are laid on the center. The runner is then built and the center weighted for pouring.

It is interesting to note in the following table, the tabulations given in regard to the knowledge of measurements

required of the men in this factory. The superintendent, foremen, pattern makers, and designers are only ones who need to know measurements. Eighty five percent of the men employed in this factory come under the third class specification. In the "jar", "ram", "power roll over and pattern drawing machines" the only work to be done by the operator is shoveling the sand and operating the machine. Unskilled labor is equally proficient for these duties as the highly skilled molder.

Table XXII

Number of Men Employed Who Need to Know Various Degrees of Accuracy in the Manufacturing of the Castings[1]

Employes	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Manager	1	.004				
Stenographic Force					8	.03
Sales Department					3	.019
Shippers and Handlers					8	.04
Factory Foremen	3	.019	2	.008	12	.06
Pattern Makers	7	.04	4	.02		
Workers					143	.70
Engineering and Designing	2	.008				
Tool and Repair Dep't.	2	.008	7	.03		
Totals[2]	15	.079	13	.058	178	.849

Number of men in the first class	15
Number of men in the second class	13
Number of me in the third class	174
Total	202
Percentage of men in the first class	.079

1. Data were given by the Plant Superintendent
2. Accurate to May 1, 1931

Percentage of men in the second class	.058
" " " " " third "	.849
Total	.986

Conclusion

Total Number of Different Tables of Denominate Numbers Used in the Vulcan Iron Works

A. Purchasing

Avoirdupois

Cubic

Board

Unit

Gallon

Hundred-eight

In comparing the measurements used in the purchasing of materials with the other three industries listed, similar tables of denominate numbers will be found.

The following tabulations show the units found in the different tables of denominate numbers listed under "A".

A. Purchasing

1. Avoirdupois 3 units

Gross Ton

Ton

Pound

Iron, coke, copper, and green sand are purchased by the ton. Acids, bases, sulphur, and grease are purchased by the pound. Coal is purchased by the gross ton.

2. Board 1 unit

Board Foot

The board foot is used in the purchasing of lumber for the crating of casts.

3. Liquid 1 unit

Gallon

Used in the purchasing of light oils and chemicals.

4. Cubic 1 unit

Cubic Yard

The unit used in purchasing of sand for molding purposes.

5. Unit 1 unit

Gross

The common unit of measurement used in the purchase of talc pencils for marking hot metals

The units found in the different tables of denominate numbers listed above are similar to those found in the study of the Fafnir Ball Bearing Company, the P. and F. Corbin Company, and the Stanley Rule and Level Company.

The knowledge of these measurements need to be known only by two men employed in the Vulcan Iron Works. All materials are purchased by them.

Measurements are not used in the selling of the castings in the New Britain foundry. This particular factory works on patterns which are kept in stock or those which are sent to them from the general plant in New Haven, Connecticut.

Total number of items listed in study

Purchasing, Manufacturing and Selling

1. Fafnir Ball Bearing Co.	44
2. P. & F. Corbin Co.	111
3. Stanley Rule & Level Co.	100
4. Vulcan Iron Works	23
Total	278

Total Number of possible units of measurements listed for study

1. Advoirdupois	5	units
2. Linear Measure	6	"
3. Cubic "	5	"
4. Square Measure	6	"
5. Paper Measure	9	"
6. Measure of Angles	5	"
7. Unit Measure	6	"
8. Metric-Weight	10	"
9. " Length	8	"
10. Board Measure	1	"
11. Liquid "	6	"
Total	67	units

FREQUENCY OF MEASUREMENTS USED IN THE FOUR INDUSTRIES

PURCHASING

	Fafnir Ball Bearing	P.&F. Corbin	Stanley Rule & Level	Vulcan	Totals
1. Gross Ton	1	1	1	1	4
2. Ton	1	7	3	4	15
3. Pound	9	15	8	8	40
4. Foot	1	1	4	1	7
5. Gallon	5	6	4	2	17
6. Board Foot	1	1	1	1	4
7. Cubic Yard	1	1	1	1	4
8. Hundredweight	1	1	1	3	6
9. Quire		1	1		2
10. Gross	3		2	1	6
11. Kilogram	1		1		2
12. Inch	4		2	1	7
13. Unit	1		1		2
14. Square Foot	1				1
Totals	30	34	30	23	117

Frequency Of Measurements Used In The Four Industries

Selling
and
Manufacturing

	Fafnir Ball Bearing	P. & F. Corbin	Stanley R.& L.	Vulcan Iron Works	Totals
1. Inch	20	292	182	0	494
2. Pound		100	6		106
3. Dozen		77			77
4. Pair		42	6		48
5. Ounce		14	16		30
6. Gross		3			3
7. Foot		3	3		6
8. Millimeters	52				52
9. Angles	—	—	4	—	4
Totals	72	531	217	0	820

Number of men employed and classifications in the industries studied

	First Class		Second Class		Third Class	
	No.	%	No.	%	No.	%
Fafnir Ball Bearing	434	.702	20	.01	177	.278
P. & F. Corbin	136	.113	41	.026	1310	.859
Stanley Rule and Level	92	.192	37	.091	327	.709
Vulcan Iron Works	15	.079	13	.058	178	.849
Totals	677		111		1988	

A. Number of men employed

First Class	677
Second Class	111
Third Class	1988
Total	2776 men

B. Percentage of men employed

First Class	.243
Second Class	.039
Third Class	.715
Total	.997

Tolerances

The tolerances used by the Stanley Rule and Level Company are practically the same as those used by the P. & F. Corbin Company. There are generally what is known as three classes of tolerances in the manufacturing of tools and hardware. The first is the "specially close dimension" which is usually plus or minus .001. The second class is the "less particular to the plan" and is usually plus or minus .003. "The general class" as called by both factories, is plus or minus .005. These tolerances are always designated on the draftsman's prints.

On all orders to the Ludlum Steel corporation and the United States Steel Corporation, tolerances plus or minus .005 are designated. A closer tolerance would mean an increase in cost. Price lists of these corporations always include tolerances.

The ball bearing of the Fafnir Company are accurate to size within .00005 inches. This industry is one which requires a minute degree of accuracy. This accuracy demanded by the automobile manufacturers, etc., is for the purpose of giving the bearing longer life. Through testing on roads, it has been found that bearings made to these specifications avoid cracking.

According to the Plant Superintendent of the Vulcan Iron Works, no fine degree of accuracy is necessary.

Tentative Conclusions

In so far as this study is concerned the data here presented justify the following conclusion:

1. Out of the 67 possible units of the 11 tables used by the four companies in purchasing, manufacturing and selling, only 18 units were used.

2. Over 61% of the persons employed did not need to use or understand any unit of measurements. In other words 39% are experts who have been scientifically trained in technical schools or in the factory. This percentage is unusually high due to the large number of experts in the Fafnir Ball Bearing Company. This industry requires a minute degree of accuracy in measurements on the part of most men. Omitting the Fafnir Company, the per cent not using measurements would equal 80%.

3. A table of measurements is never used in its entirety. Only one unit of measurement is necessary as a rule for any one purpose. For example, those men who are working in the factory using the inch or part of an inch, seldom have occasion to use the yard.

4. The units of measurements used in the purchasing of raw materials, differ from those used in manufacturing the different articles. The units used in the purchasing of raw material are usually those of volume and capacity. The units of linear measurements show a greater frequency in manufacturing.

5. In the four industries studied, the inch and the pound were the most common units of measurements for manufacturing and selling, the pound rating second in frequency.

6. A knowledge of tolerances, that is the fractional allowance for the variation from standard, involves only the men who are called experts, usually the designers,

and the men employed in the engineering departments. In the Fafnir Ball Bearing Company, the majority of men come under the classification of those needing to know fine measurements.

7. Whatever degree of accuracy is commonly called for, that degree of accuracy becomes the unit of measurement in the operation involved.

8. A knowledge of standard tolerances involves only the men employed in the engineering and designing departments. Others may be using a gauge which measures tolerances but do not need to understand the actual measurements involved. (Gauges are marked for the men as "go" and "no go")

Tentative Conclusion

Application of Study

In so far as this study is concerned the data here presented justify the following conclusion:

The teaching of addition, subtraction, multiplication and division of compound denominate numbers has little or no value. These processes are found in most of the textbooks now in use. In the entire study no use was found for these processes. Should the schools continue to teach that which has no use in life?

The memorizing of tables of weights and measurements as listed on page 11 has little or no value. No complete table of denominate numbers was used by any of the men employed in the four industries studied. When the pupil has once actually purchased an article, it should not be difficult for him to apply the preferred unit of measurement to that particular article on ensuing occasions. The important thing is for the child to know commodities; the unit of measurement follows.

Reduction ascending and reduction decending have no value in the industries studied, with the exception of the cost department which makes estimates on various "jobs". This is confined to four men in the four industries studied. Reduction ascending and reduction decending as processed have little or no justification for continuation as school exercises.